U.S. Department of Energy
Energy Efficiency and Renewable Energy

Office of the Biomass Program

RESEARCH AND DEVELOPMENT ACTIVITIES BY ROADMAP CATEGORY

Prepared for:

Biomass Technical Advisory Committee
and the
Interagency Biomass Research and Development Board

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Table 1 – DOE/OBP Funding by Roadmap Subcategory / Dept. of Energy OBP R&D Area		Biotechnology & Plant Physiology	Feedstock Handling	Thermochemical Conversion	Bioconversion	Biorefinery Integration	End Products & Distribution Systems	Public Policy Measures (3)			Other (2)	
								Planning & Analysis (1)	Education Initiative	State Grants		
Feedstock: Biotechnology & Plant Physiology	**FY04**	**1,000**										**1,000**
Feedstock Infrastructure	**FY04**		**2,000**									**2,000**
Thermochemical Conversion R&D	**FY04**			**17,304**								**17,304**
Thermochemical Production Integration	**FY04**			**8,000**								**8,000**
Bioconversion R&D	**FY04**				**21,104**							**21,104**
Bioconversion Production Integration	**FY04**					**23,250**	**1,500**					**24,750**
Small Modular Biopower	**FY04**					**4,000**						**4,000**
Total	***FY04***	***1,000***	***2,000***	***25,304***	***21,104***	***27,250***	***1,500***					***78,158***

(1) OBP Planning and Analysis activities which can be used to support Roadmap category on public policy measures to support biomass development

(2) includes $10.6 million held for earmarks

(3) For FY04, an estimated $4,000,000 will be taken on a prorated basis from all categories for analysis and corporate initiatives. This also includes $400,000 for program direction from Interior.

Project Title	Recipient	FY03 $	Page No.
Biotechnology and Plant Physiology			
PHAs in Plants (Biomass Biorefinery for Production of Polymers and Fuel)	Oak Ridge National Laboratory (ORNL)	$100,000	8
Enhancement of Bio-Based Products from Sorghum Grain, with Optimized Production	Orion Genomic	$1,511,049	8
Hybrid Poplar Tree Research (Earmark)	Forest Service	$496,750	9
Category Total		**$2,107,799**	
Feedstock Handling			
Agricultural Engineering Systems and Sustainability	Oak Ridge National Laboratory (ORNL)	$1,999,980	10
Collection, Commercial Processing, and Utilization of Corn Stover: Harvesting Technology Plus	Cargill-Dow/Mat Inc.	$954,430	12
Develop Roadmap for Harvesting and Logistics R&D	Idaho National Engineering and Environmental Laboratory (INEEL)	$600,000	13
One-Pass Harvester and In-Field Separation of Wheat Grain and Straw	Idaho National Engineering and Environmental Laboratory (INEEL)	$140,997	14
Category Total		**$3,695,407**	
Thermochemical Conversion			
CFD Modeling, Shape Optimization and Feasibility Testing of Advanced Black Liquor Nozzle Designs for Improved Energy Efficiency	Idaho National Engineering and Environmental Laboratory (INEEL)	$225,000	15
Computational Fluid Dynamics (CFD) Modeling of Boise Biomass Gasifier	Argonne National Laboratory (ANL)	$125,000	15
Demonstration of Black Liquor Gasification at Big Island	National Energy Technology Laboratory (NETL)	$8,408,000	16
Development of Corrosion-Resistant Chromium Rich Alloys for Gasifier and Kraft Recovery Boiler Applications	Oak Ridge National Laboratory (ORNL)	$270,000	16
Development of Materials for Gasification	Oak Ridge National Laboratory (ORNL)	$572,750	17
Modeling of Georgia Pacific Gasifier	National Energy Technology Laboratory (NETL)	$971,000	17
Evaluation of RVS Sorbent	National Energy Technology Laboratory (NETL)	$670,000	18
Gasification Program Technology Support and Project Management	National Energy Technology Laboratory (NETL)	$1,580,000	18
Pulsed Black Liquor Reformer Materials Evaluation	Oak Ridge National Laboratory (ORNL)	$358,000	18
SynGas Platform Advanced Biomass R&D: Syngas Production	National Renewable Energy Laboratory (NREL)	$2,580,000	19
R&D Activities at PNNL, Including Technical Support, Wet Gasification, and Liquid Fuels Gasification and Pyrolysis	Pacific Northwest National Laboratory (PNNL)	$2,200,000	20
Capital Equipment	National Renewable Energy Laboratory (NREL)	$1,220,000	22
Gasification of Iowa Switchgrass (Earmark)		$496,750	22

Biomass Gasification Facility in Birmingham, AL (Earmark)	Biomass Gasification Research Facility	$1,987,000	22
Analytical Studies and Program Integration at NREL Related to Syngas Platform	National Renewable Energy Laboratory (NREL)	$1,700,000	23
Polyols Research and Development	Pacific Northwest National Laboratory (PNNL)	$474,925	23
High Pressure Combinational Catalysis Unit	Pacific Northwest National Laboratory (PNNL)	1,500,000	23
Category Total		**$25,338,425**	
BioConversion			
Development of Improved Chemicals and Plastics from Oilseeds	Dow Chemical	$794,374	24
Affordable Resins and Adhesives from Optimized Soybean Varieties	University of Delaware	$912,744	24
Industrial Membrane Filtration and Short-Bed Separation Systems for Separating Monomers from Heterogeneous Plant Materials	Idaho National Engineering and Environmental Laboratory (INEEL)/Amalgamated Research	$520,000	25
Development of Microorganism for the Fermentation of Agricultural Feedstocks to Chemicals	Cargill Dow Polymer	$375,426	26
Sugar Platform Integration	National Renewable Energy Laboratory (NREL)	$4,472,383	26
Sugar Platform Advanced Biomass R&D Products from Sugars: Fermentation Platform	National Renewable Energy Laboratory (NREL)	$1,215,451	27
Sugar Platform Advanced Biomass R&D: Cellulase Enzymes	National Renewable Energy Laboratory (NREL)/Genencor/Novozymes	$9,972,898	28
Sugar Platform Advanced Biomass R&D: Pretreatment	National Renewable Energy Laboratory (NREL)	$3,304,268	29
PHAs in Plants (Biomass Biorefinery for Production of Polymers and Fuel)	Metabolix	$1,400,000	30
Miscellaneous Capital Equipment	HPCC-MS	$561,750	*30*
Category Total		**$23,529,294**	
Biorefinery Integration			
Collaboration with USFS Forests Products Laboratory on Gasifier Demonstration	National Renewable Energy Laboratory (NREL)	$2,000,000	31
Corn Ethanol Production Improvements	National Renewable Energy Laboratory (NREL)/ Advanced Corn Mills -USDA / Broin / High Plains	$840,000	31
GovWorks/Department of the Interior (Obligated to the Six Projects)	GovWorks/Department of Interior	$1,265,000	32
*A Second Generation Dry Mill Biorefinery**	Broin and Associates Inc.	$1,596,000	32
*A New Biorefinery Platform Intermediate**	Cargill, Inc.	$2,009,000	32
*Making Industrial Bio-Refining Happen**	Cargill Dow, LLC	$9,041,000	33
*Integrated Corn-Based Bio Refinery (ICBR) Project**	E.I. du Pont de Nemours & Co., Inc. (DuPont)	$4,094,000	33
*Advanced Biorefining of Distiller's Grain and Corn Stover Blends: Pre-Commercialization of a Biomass–Derived Process Technology**	High Plains Corporation	$3,211,000	34

*Separation of Corn Fiber and Conversion to Fuels and Chemicals, Phase II: Pilot-scale Operation**	National Corn Growers Association	$1,054,000	34
Corn Bioproducts (Earmark)	National Corn Growers Association	$572,000	35
Mixed Waste Biorefinery Using Thermal Depolymerization in Colorado (Earmark)		$2,483,750	35
Combined Heat and Power Green Institution in Minnesota (Earmark)	Green Power Institute	$1,987,000	35
Center for Biomass Utilization	University of North Dakota	$397,400	35
Biomass Energy Resources Center in Burlington, VT	Biomass Energy Resources Center	$496,750	36
Fibrowatt Mississippi Biomass Project	Fibrowatt LLC	$496,750	36
Iowa Switchgrass at Agreed to Levels	Chariton Valley	TBD	36
Iroquois Bioenergy Cooperative (Earmark)	Iroquois Cooperative	$2,980,500	37
Michigan Biotech Institute (Earmark)	Michigan Biotech Institute	$1,987,000	37
Mississippi Ethanol (Earmark)	Mississippi Ethanol	$2,980,500	37
New FY03 Solicitation with USDA	TBD	$5,000,000	38
* *Funding data for the integrated biorefinery projects is the sum of FY02 and FY03.*			
Category Total		**$44,491,650**	
End Products & Distribution Systems for Biomass Resources			
Renewable Diesel: Industrial Oils Platform Analysis	National Renewable Energy Laboratory (NREL)	$1,500,000	39
National Agriculture-Based Industrial Lubricants Center (Earmark)	National Agriculture-based Industrial Lubricants Center, University of Northern Iowa	$993,500	39
Oxydiesel Demonstration in Nevada and California (Earmark)	AAE Technologies	$993,500	40
Category Total		**$3,487,000**	
Planning and Analysis			
Biomass Program Analysis	Argonne, Brookhaven, National Renewable Energy Laboratory (NREL), Oak Ridge National Laboratory (ORNL)	$953,191	41
Identification and Assessment of Biomass-Based Chemicals and Materials to Guide Research in the Office of the Biomass Program	Pacific Northwest National Laboratory (PNNL), National Renewable Energy Laboratory (NREL)	$581,000	41
Category Total		**$1,534,191**	
Procurement and Markets			
BuyBio DOE/Other Federal Agencies Procurement Initiative	Argonne National Laboratory (ANL)	$100,000	43
Category Total		**$100,000**	
Education Initiative			
Education Initiative	To be determined per results of solicitation	$1,000,000	44
Communication and Education		$878,000	44
Consortium for Plant Biotechnology Research Initiative (Earmark)	Consortium for Plant Biotechnology Research	$1,987,000	44
Category Total		**$3,865,000**	

State and Regional			
Regional Biomass Energy Program Management	Regional Biomass Energy Programs	$880,500	46
State Technologies Advancement Cooperative (STAC)	STAC	$1,500,000	46
EE Special Energy Project (SEP) State Grants	To be determined per results of solicitation	$600,000	46
Category Total		**$2,980,500**	
Other			
Early Reallotment of FY 2002 Unobligated Balances for Earmark	Multiple	$5,622,000	48
Miscellaneous Corporate Initiatives	Headquarters	$4,324,170	48
FY 2003 EARMARK Reserve	Various	$4,900,000	48
FY 2003 Solicitation Reserve	TBD	$5,031,166	48
Program Direction	Multiple	$761,000	49
Category Total		**$20,638,336**	
Total		**$131,767,602**	

OFFICE OF THE BIOMASS PROGRAM

ACTIVE R&D PROJECTS BY ROADMAP AREA

BIOTECHNOLOGY AND PLANT PHYSIOLOGY

Title: *PHAs in Plants (Biomass Biorefinery for Production of Polymers and Fuel)*

Roadmap: **BIOTECHNOLOGY AND PLANT PHYSIOLOGY**
Budget Key : Interior
Recipient: Oak Ridge National Laboratory (ORNL)
FY03 Plan ($): 100,000.00

Description:
The purpose of this project is to study the physical properties of a class of biopolymers produced by microbial fermentation processing of feedstock derived from green tissue plants. It is a subset of a larger project that envisions the use of U.S. agriculture to produce polyhydroxyalkanoate (PHA) polymers on a renewable basis. In the larger project, green tissue crops will be used to produce PHAs, a family of biodegradable polymers that can be processed to film, fibers, coatings, and molded objects, and can be converted to useful chemicals. (See PHAs in Plants in the Bioconversion section of this report). Current use of synthetic resins for these applications totals over 50 billion pounds per year in the U.S. The program therefore combines use of indigenous U.S. resources to produce environmentally friendly polymers and chemicals important to the U.S. economy and will provide a more neutral carbon balance in the ecosphere compared with current use of fossil based carbon for polymers, chemicals, and energy.

As a subset of the *Biomass Biorefinery*, the specific objective of this project is to measure the fundamental materials properties and processing behavior of the PHAs, their blends, and their copolymers. This includes the crystallization behavior, structure, thermodynamics, and blend compatibility of these materials.

Title: *Enhancement of Bio-Based Products from Sorghum Grain, with Optimized Production and Composition using Advanced Genomics*

Roadmap: **BIOTECHNOLOGY AND PLANT PHYSIOLOGY**
Budget Key: Interior
Recipient: Orion Genomic
FY03 Plan ($): 1,511,049.00

Description:
This project integrates a team of multi-disciplinary researchers to identify and sequence the genes of sorghum, discover the links between specific genes and the composition of grain, use plant breeding to improve the grain composition, and identify a potential portfolio of processed output products. The main desirable traits include yield per unit resource used, increased starch content, and enhanced starch types that will enable more efficient processing of sorghum to bio-based products as well as acceptable agronomic traits and drought tolerance for improved economics of production. Processing technologies will be selected to optimize the use of enhanced sorghum grain. Expected output products will include ethanol, lactate, succinate, acetate, citrate; uses for the remaining fiber and protein will also be investigated.

Title: *Hybrid Poplar Tree Research (Earmark)*

Roadmap:	**BIOTECHNOLOGY AND PLANT PHYSIOLOGY**
Budget Key:	Energy and Water Development
Recipient:	Forest Service
FY03 Plan ($):	496,750.00

Description:
This project will continue hybrid poplar tree research in the state of Wisconsin.

FEEDSTOCK HANDLING

Title: *Agricultural Engineering Systems and Sustainability*

Roadmap: **FEEDSTOCK HANDLING**
Budget Key: Energy and Water Development
Recipient: Oak Ridge National Laboratory (ORNL)
FY03 Plan ($): 1,999,980.00

Description:

Sustainable Biomass Supply - This research area is divided into two major tasks and several subtasks. The task descriptions are provided below.

- **Environmental Sustainability Advanced R&D** - The goal is to ensure that quantities of biomass sufficient to support a significant bioindustry can be collected sustainably at the lowest possible cost. The cost of harvesting agricultural residues is closely correlated to the amount of residue collected per acre of cropland. Higher collection rates reduce costs; lower rates increase costs. More subtle effects will come into play when advanced collection technologies offer the opportunity to change the quality, as well as the quantity, of the residue returned to the field. The primary objective of current research is to develop procedures and decision-making tools that will allow on-farm assessment of sustainable residue removal levels. These data and tools will help to reduce residue costs by determining the optimum balance between the amount of residue collected and the amount left to perform environmental services. The largest project in this area is a cooperative effort with the USDA Agricultural Research Service on the implications of corn stover removal in four states. Research includes comparing soil respiration rates, soil microbial activity, crop production efficiency and grain yields, carabid beetle population trends, and soil chemical and physical properties with and without residue removal.

- **Resource Availability Advanced R&D** - This research area, conducted primarily at ORNL in collaboration with university partners, is responsible for developing information on the location, price, quantity, and quality of biomass resources and quantifying their associated environmental and socioeconomic benefits. This information is provided at both the policy and planning level to DOE and other stakeholders and to projects directly involved in the development of biorefinery technologies. Activities include developing and applying modeling tools that integrate resource information, sustainability research, and feedstock engineering to (1) estimate the supply (location, cost, quantity, and quality) of biomass feedstocks at the county, state, and national level under current and potential policy and regulatory settings and (2) estimate the benefits (environmental and socioeconomic) of producing and using those biomass feedstocks. In FY 2003, resource availability research will be primarily focused on estimating agricultural residue quantities and costs given environmental constraints and variations in residues density (tons/acre). The estimates will be at a county level and cover 40 agricultural states.

Harvest and Collection Methods Advanced R&D - The objective of this research area is to develop advanced concepts and equipment for feedstock supply at the front end of the process.

Harvest and handling costs (and therefore feedstock costs) are expected to be reduced significantly through the development of new or modified equipment to provide feedstock for biorefineries in a manner that meets cost and availability requirements.

- **Baseline Data for Harvesting** - ORNL engineers and economists, together with subcontractors, have established and published average baseline costs for traditional methods of collecting, handling, and transporting corn stover based on literature reviews. Recently initiated research at the University of Kentucky is collecting operational data on actual efficiency (and cost) of corn stover harvesting with existing forage harvesting equipment. They are also testing the use of precision farming and remote sensing for optimizing field operations in corn stover collection. Together these efforts provide information for reducing costs of current technology. They also establish baselines against which the effectiveness of new equipment and systems innovations need to be measured.

Transportation and Storage Advanced R&D - The objective of this research area is to assess the benefits and detractions of the various available methods for treatment, transportation, and storage of lignocellulosic biomass for biorefineries.

- **Treatment Prior to Transport and Storage -** ORNL is conducting three research activities related to this task:
  - ORNL, in collaboration with the University of Kentucky, is comparing changes in the moisture content and dry matter loss that occurs as a result of outside storage in large round bales in both covered and uncovered conditions. This information will assist in developing low cost methods to reduce storage losses in baled storage.
  - ORNL sponsored work at the University of Tennessee is collecting data to define the mathematical relationship between moisture content, time of harvest, time of drying, and weather conditions. Such data is needed to model and optimize feedstock harvest and handling processes.
  - ORNL staff are working in collaboration with staff at the University of British Columbia to compare the economics of various densification processes in preparation for a stage gate analysis of a new densification (pelleting) technology under consideration for development. Collaborations are also being developed with small businesses to proceed with further evaluation of the new pelleting technology. While pelleting may be particularly useful for improving feedstock feeding for gasifiers, the technology is also valuable for reducing transportation and storage costs and hazards associated with dry storage.

Integrated Supply Systems

- **Logistics Modeling -** Addressing all of the technology areas in an isolated manner is not sufficient; they must be addressed in context of the overall biomass supply chain. This will be done initially through supply logistics modeling and integrated analysis that considers economic, ecological, and supply logistics and process simultaneously. One objective is to develop a modeling tool that will allow evaluation and comparison of alternative supply system configurations.

- **Integrated Analysis** - Analysts from ORNL and INEEL will work with many other groups to ensure that feedstock supply considerations are appropriately integrated into models and analyses of biorefining enterprises and industries and that the environmental and socioeconomic benefits of biomass feedstocks are included in such analyses. The resource assessment component of integrated analysis uses a systematic, integrated approach that depends heavily on hierarchically linked "process-type" models to encompass economic, geographic, and environmental constraints.

Title: *Collection, Commercial Processing, and Utilization of Corn Stover: Harvesting Technology Plus*

Roadmap: **FEEDSTOCK HANDLING**
Budget Key: Interior
Recipient: Cargill-Dow/Mat Inc.
FY03 Plan ($): 954,430.00

Description:
The goals for this project are to (1) develop and test new technologies that harvest, transport, store, and separate corn stover to consistently supply clean, raw materials to downstream processors in the bioproducts industry, and (2) to engineer a fermentation system to meet performance targets for lactic acid and ethanol manufacturers. Specifically, the project will seek to decrease the unit cost of raw materials for the bioproducts industry, improve consistency and quality of raw materials, neutralize the impact of weather conditions on raw materials, eliminate the fire hazard of stored biomass, develop harvest and transport equipment for commercialization, encourage wide-spread adoption of stover harvest by farmers, and develop fermentation processes that meet performance targets required for the conversion of corn stover to lactic acid and other chemical derivatives.

Task 1.1 –Harvesting Technology - ISU (Prof. Graeme Quick) & John Deere (To harvest, collect, densify and transport corn stover, practically free of dirt, at an economical level, aiming for well below $30/ton delivered.); Task 1.2 – Stover Characteristics IronHorse Farms, Inc. (Establish benchmarks and indicators in order to improve understanding of present day Stover inorganic content and areas of concentration, production capabilities, harvest consistency, and transport capacities); Task 2.1 Storage System and Preservation – Mat, Inc. (Eliminate fire hazard and improve preservation of stored biomass by ensiling); Task 2.2 – Analytical Support - Midwest Laboratory (Provide analytical expertise); Task 2.3 Investigate potential collection centers locations for one pass harvest and 'wet storage" IronHorse Farms (Investigate the western Iowa, eastern Nebraska area for potential collection sites for one pass harvest. Factors such as truck and rail access, existing grain infrastructure (elevators and "on farm") will be considered. In addition the options of combined transport from the farm and where grain separation should take place will be considered); Task 2.4 Distribution of Dry Weight in Stover – IronHorse Farms (Establish benchmarks as to distribution of dry weight and validate most practical Stover storage methods); Task 3 Effect of Corn Stover Storage on Fiber Quality – ISU (Prof. Monlin Kuo) (The main objective of this proposed project is to determine effects of corn stover bales and processed corn stover pulp storage on fiber quality. Unprocessed corn stover and processed pulp will be periodically sampled and analyzed for changes in chemical composition and the morphological and mechanical properties of corn fibers); Task 4.1 Plant Component Separation - Mat Inc. (Overall Objectives: Design, build and evaluate a plant part

separation system capable of removing contaminates and separating components of the corn plant.); Task 4.2 Component Separation – IronHorse Farms, (Establish benchmarks as to distribution of nutrients and moisture in standing Stover. Assess the effects of targeting specific segments for separation during harvest); Task 5.1 – Automation - Mat Inc. (Automate sampling of the loads of Stover at the delivery scale in order to reduce demands on labor, streamline sampling and analytical process and reduce 0time required for transport vehicles at the collection point); Task 7 Cargill Dow Fermentation Development; Task 8.1 – Producer/Converter Business Relationship Analysis, Iowa State University Extension; Task 8.2 - Producer/Converter Business Relationship Support – IronHorse Farms (Establish benchmarks to increase understanding and encourage early adoption of best Stover harvest practices by producers, as well as early utilization by converters).

Title: *Develop Roadmap for Harvesting and Logistics R&D*

Roadmap:	**FEEDSTOCK HANDLING**
Budget Key:	Energy and Water Development
Recipient:	Idaho National Engineering and Environmental Laboratory (INEEL)
FY03 Plan ($):	600,000.00

Description:
This task will set the agenda for feedstock supply R&D in the next 5 years. Recent investments by industry, the U.S. DOE, USDA and others have done much to begin addressing the issues and challenges associated with development of a sustainable bio refining industry. The Biorefinery Feedstock Supply Program (BFSP) will facilitate the development of the Feedstock Harvesting and Supply Logistics Research and Development Roadmap (Feedstock Roadmap) together with the major stakeholders to ensure the profitability of biorefineries. This roadmap will include input from existing studies and demonstrations, past agriculture and biofeedstock experience and most importantly input from colloquies with the technology, industry, environmental and policy stakeholder communities.

The roadmap will focus on corn stover and cereal straws, the feedstocks of choice of companies currently involved in biorefinery technology development. The near-term goal is to have a feedstock supply system developed sufficiently to support the first lignocellulosic sugar biorefinery, which is expected to be in production by about 2007. The system must be improved and expanded to support as many as seven or more lignocellulosic sugar biorefineries that may be in operation by 2020 as well as several biorefineries using the syngas platform. For ease in ensuring good cross-representation of crop residue feedstock issues throughout the Feedstock Roadmap process, the supply chain will be categorized into four areas. These include Biomass Supply, Harvest and Collection, Treatment, Transportation and Storage, and Biomass Preprocessing. As defined here, Biomass Supply will encompass both the Sustainability requirements and the Resource Availability barrier areas. Systems Integration issues will be addressed within each of these areas to ensure that no single area is roadmapped independently of the others and thereby ensure an integrated end-product.

INEEL will lead the organization of the feedstock roadmapping process with active input and participation of ORNL and USDA staff. After completion of the roadmap, this task will transition to a planning and technical coordination activity. It is proposed that a Technical Coordination Advisory Panel (TCAP) be established using representative stakeholders and

institutions involved in the roadmapping process. This group will facilitate integration, coordination and communication at many different levels to overcome all barriers associated with developing feedstock supply systems. The specific duties and responsibilities of the TCAP will be further addressed in future planning documents.

Title: *One-Pass Harvester and In-Field Separation of Wheat Grain and Straw*

Roadmap:	**FEEDSTOCK HANDLING**
Budget Key:	Energy and Water Development
Recipient:	Idaho National Engineering and Environmental Laboratory (INEEL)
FY03 Plan ($):	140,997.00

Description:
In a project led by INEEL, work is continuing on the multi-component harvester for wheat straw. Partners include INEEL, CNH Global N.V., and Iowa State University. The goal of this work is to develop a single-pass, multi-component combine that will separate both the grain and stems from straw, and builds on the selective harvest strategy. The research focuses on reducing harvesting costs by limiting harvesting to a single pass across the field, using straw components for the most desirable end-use, and potentially increasing the total biomass available for harvest (this depends on the sustainability issues in the particular locality).

THERMOCHEMICAL CONVERSION

Title: *CFD Modeling, Shape Optimization and Feasibility Testing of Advanced Black Liquor Nozzle Designs for Improved Energy Efficiency*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key: Interior
Recipient: Idaho National Engineering and Environmental Laboratory (INEEL)
FY03 Plan ($): 225,000.00

Description:
This project aims to improve the energy efficiency of the recovery boiler by optimizing black liquor splash plate nozzle performance. To achieve this, research will be conducted to produce droplets of the desired size (about 3mm) having very narrow droplet size distribution, and having a uniform spray pattern within the furnace. Specific project tasks include laboratory testing of black liquor nozzles, development of a CFD model of black liquor spray nozzles, and design and testing of full-scale nozzles at industrial conditions.

Title: *Computational Fluid Dynamics (CFD) Modeling of Boise Biomass Gasifier*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key: Interior
Recipient: Argonne National Laboratory (ANL)
FY03 Plan ($): 125,000.00

Description:
The overall project objective is to develop and validate CFD models of key components/processes in the GTI/Boise advanced biomass gasification based power generation system for use in finalizing their design and subsequent commercial deployment. Specific technical objectives of the proposed support program are:

1) Develop a 3-D model of the GTI biomass gasifier using ANL's "state of the art" multiphase (solid, gas and liquid) reacting flow CFD code.

2) Perform initial validation of the gasifier model with data provided by GTI and available from the literature.

3) Use the validated gasifier model to conduct detailed parametric sensitivity and optimization studies on the gasifier and overall system performance.

4) Incorporate a rigorous spectral radiation module into the GTI Stoker boiler model.

5) Validate the CFD models with pilot and demonstration scale data.

The models developed will be used by GTI/Boise to help finalize the design of their gasifier/power system. The validated models will also be made available to the forest products industry.

Title: *Demonstration of Black Liquor Gasification at Big Island*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key: Interior
Recipient: National Energy Technology Laboratory (NETL)
FY03 Plan ($): 8,048,000.00

Description:
Georgia-Pacific was awarded a cooperative agreement to demonstrate black liquor gasification at the Big Island, Virginia facility. The project is a 5-year commercial scale demonstration designed to prove the viability of black liquor gasification technology in the forest products industry.

This project will enable the development, scale-up, and commercialization of gasification technologies for the forest products industry providing domestic mills the opportunity to replace recovery boilers that are reaching retirement age with a new, more energy and environmentally efficient technology. This technology offers great potential for improved capital effectiveness, energy efficiency, environmental performance, global competitiveness, and safer working conditions for the forest, wood, and paper industries. These advantages include:

- ?? The ability to increase electrical power production capacity by over 200 percent.
- ?? The potential to reduce greenhouse gas emissions by over 30 million metric tons of carbon per year.
- ?? Providing United States facilities with significantly more effective and efficient powerhouses compared to currently growing segment of the global industry.
- ?? Increasing pulp yield per unit of wood, reducing pulping energy consumption, and increasing pulp quality.
- ?? Cross-cutting applications to other industries, including agricultural, pharmaceutical, and petrochemical.

Georgia-Pacific and its technology partners will design, construct, and operate a black liquor gasifier integrated into the existing mill operations with deployment demonstration beginning in early 2008. When completed, this project will provide the entire chemical recovery required by the facility.

Title: *Development of Corrosion-Resistant Chromium Rich Alloys for Gasifier and Kraft Recovery Boiler Applications*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key: Interior
Recipient: Oak Ridge National Laboratory (ORNL)
FY03 Plan ($): 270,000.00

Description:
The objective of this project is to develop a new family of molten smelt resistant chromium-rich alloys with sufficient ductility and toughness to permit use as structural components and/or coatings for spent pulping chemicals recovery. We have teamed with gasifier suppliers and a

forest products company to allow for in-plant exposure of coupons/prototype components manufactured from the developmental alloys and to allow for a smooth and rapid transition of this technology into commercial practice should we be successful. The proposed work will significantly leverage experience and laboratory scale molten salt testing infrastructure gained in previously funded efforts for recovery boiler materials and refractory materials for gasifiers.

Specific tasks of the project include:
- Evaluation of corrosion performance of multi-phase CR-rich Cr-X alloys;
- Development of corrosion resistant Cr-X alloys with improved mechanical properties, especially with regard to ductility;
- Optimization studies of Cr-MgO base alloys;
- Laboratory studies to optimize the corrosion resistance of Cr-MgO;
- Studies to identify coating application methods; and
- Exposure of promising alloy samples to actual industrial/plant pulping chemicals smelts.

Title: *Development of Materials for Gasification*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key: Interior
Recipient: Oak Ridge National Laboratory (ORNL)
FY03 Plan ($): 572,750.00

Description:
The primary objective is the development of cost-effective materials with improved performance in gasifier environments to answer the material challenges presented by black liquor gasification. Refractory materials may be selected/developed that either react with the gasifier environment to form protective surfaces in-situ; are functionally-graded to give the best combination of thermal, mechanical, and physical properties and chemical stability; or are relatively inexpensive, reliable materials. Additionally, the effect of the materials on the vessel design must be investigated. A model of the refractory containment system will be developed. The model will provide for (1) the optimization of geometry, (2) selection of the most cost effective refractory, and (3) estimation of the expected lifetime.

Title: *Modeling of Georgia Pacific Gasifier*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key: Interior
Recipient: National Energy Technology Laboratory (NETL)
FY03 Plan ($): 971,000.00

Description:
Modeling of the Big Island Heat Exchanger and Gasifier - This project aims to adapt the MFIX computer code to predict the detailed behavior of a black liquor gasifier through alteration of two subroutines within the code. Additionally, this model development activity will be used to study the flow and heat transfer properties of the heat exchanger geometry being installed at the Big Island Paper Mill.

Title: *Evaluation of RVS Sorbent*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key: Interior
Recipient: National Energy Technology Laboratory (NETL)
FY03 Plan ($): 670,000.00

Description:
Evaluation of RVS-1 Sorbent for Removal of Sulfur from Black Liquor Gasification - It is desirable to incorporate a hot/warm gas cleanup unit with RVS-1 sorbent in the MTCI's Black Liquor Steam Reformer system to remove sulfur gases. The objective of this proposal is to conduct tests with RVS-1 sorbent in order to investigate whether the sorbent can potentially be used to remove sulfur from the synthesis gas generated from MTCI's Black Liquor Steam Reformer system.

Title: *Gasification Program Technology Support and Project Management*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key: Interior
Recipient: National Energy Technology Laboratory (NETL)
FY03 Plan ($): 1,580,000.00

Description:

Chemical Kinetic Analysis of Black Liquor Steam Reforming - The objectives for this investigation are as follows: 1) perform a mass balance on an individual particle, grossly identifying components that are partitioned into each phase of the steam reformer; 2) establish the general chemistry occurring; and 3) develop generalized intrinsic kinetics.

Support environmental assessment (EA) for Black Liquor Biomass demonstration projects - The objective of this project is to support NETL's Black Liquor Biomass Gasification Program through assistance in the development of an Environmental Assessment (EA) for the BL/Biomass demonstration projects. This activity will also include support to the Biomass Office in updating the March 2001 NEPA report with recent events, including a list of biomass-related NEPA documents prepared since that date.

Title: *Pulsed Black Liquor Reformer Materials Evaluation*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key: Interior
Recipient: Oak Ridge National Laboratory (ORNL)
FY03 Plan ($): 358,000.00

Description:
The objective of this project is to collect data on the behavior of metals and refractories in a system that replicates the conditions in a PulseEnhanced Steam Reformer. This will be accomplished by modifying the Process Development Unit (PDU) at the MTCI (Manufacturing

and Technology Conversion International, Inc.) facility in Baltimore, MD so that it will accommodate a 12-tube pulse heater module that will be inserted in the PDU bed in a manner that reproduces the arrangement in a full-scale unit. Metallic and refractory samples will be removed at regular intervals and these samples will be thoroughly examined to obtain information that will help identify the most appropriate materials for the demonstration system.

Title: *SynGas Platform Advanced Biomass R&D: Syngas Production*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key: Energy and Water Development
Recipient: National Renewable Energy Laboratory (NREL)
FY03 Plan ($): 2,580,000.00

Description:
SynGas Processes and Requirements - The objective of this task is to identify R&D needs for biomass syngas conversion processes that will allow successful integration with existing gas-to-liquids technologies. Many commercial processes exist for fuels, chemicals, and power from syngas. This task will summarize these processes/products including commercial activities, process conditions, syngas composition, syngas cleanliness requirements, and economics. An extensive review of the literature will be performed and a report compiled that 1) provides technology descriptions for chemical pathways to produce liquid fuels and chemicals from syngas; 2) identifies gas impurity specifications for identified process, when available; 3) includes process economic data with minimal analysis; and 4) provides a synopsis of research needs to develop commercial biomass-derived syngas to fuels and chemicals processes. The report will be compiled in phases based on each syngas conversion process. The goal is to condense each process into a separate technology brief. A minimum of 14 processes will be examined including Fischer-Tropsch liquids (including upgrade products like LPG, naphtha, diesel, kerosene, lubes, and waxes), syngas-to-methanol processes (including DME production and methanol-to-gasoline), and additional processes such as ethanol, mixed alcohols, olefins, oxo-chemicals, hydrogen, and ammonia syntheses.

Gas Clean-up - The objective of this task is to develop and evaluate gas cleanup and conditioning systems, including tar steam reforming and hot gas particulate removal, required for the production of fuels and chemicals from syngas derived from biomass gasification. While fuels synthesis processes will require very specific gas compositions and contaminant removal levels, the work proposed below will apply to any selected process, and to turbine and fuel cell processes as well. The Gas Cleanup Task is organized into four (4) subtasks. The Hot Gas Particulate Removal Subtask includes the evaluation and implementation of improved and novel particulate removal strategies. This will require a capital equipment purchase of a Malvern particle size analyzer to measure on-line, continuous particle size distributions before and after high temperature filters for evaluation of particle removal effectiveness and pressure losses. The performance goals are to eliminate system upsets during on-line filter cleaning and to reduce the time-averaged pressure drop across the filters. Catalytic tar decomposition remains a key technical hurdle to commercializing biomass gasification. When fabricated and installed, the Catalytic Tar Reforming Reactor for the TCPDU Subtask will add an additional unit operation in NREL's Thermochemical Users Facility to extend the range of attainable product gas compositions for various applications and to conduct relatively long term testing of selected catalysts, a need identified in a FY02 literature survey. The focus of this subtask will be a

competitive solicitation to fund a subcontract for the design and construction of a fluidized bed catalytic tar reforming reactor based on input from NREL's engineers and their past experience with a similar reactor designed and tested for an industrial partner. Additional catalyst screening research in support of the previous task and the CRADA between NREL and Future Energy Resources Corporation (FERCO) of Norcross, GA will be conducted as the Catalyst Screening Subtask. NREL has been conducting catalytic tar destruction studies using a bench-scale, 2 .-diameter, fluidized bed reactor system (2FBR) to condition a slip-stream of hot, raw product gas from the TCPDU. These screening studies will continue in FY03. Potential catalysts to be screened in FY03 will include catalysts being evaluated by FERCO in Vermont, robust new catalysts being developed for fluidized bed applications, and other potential catalysts investigated by other researchers such as dolomites, iron sinter, olivine, and novel Ni-containing catalyst formulations. The Biomass Gasification Reaction Chemistry subtask will focus on understanding biomass gasification reaction chemistry as it applies to tar formation and maturation by conducting fundamental, bench-scale studies in a laminar entrained flow reactor (LEFR).

Next Generation Gasifier - The objective is to develop an innovative "next generation" biomass gasifier that can produce a medium heating value product gas (approx. 400-600 Btu/scf) at a production scale of 500 kWt to 10 MWt (150kWe-3MWe or 80,000-1,600,000 gallons per year of fuel). This would enable an interface with existing and emerging small syngas to fuels catalytic conversion process (e.g., the Power Energy Fuels process for production of mixed alcohols from syngas) and with existing and emerging Small-Modular-Biomass distributed-generation power systems. The required system performance objectives will position these next-generation gasifiers to become key processing components of community or farm scale integrated biomass refineries for combined fuels, heat, and power systems. Some development of medium BTU gasifier systems has already occurred in the private sector and research community. A further objective of this task is to capture the best design features of the work to date. When possible, these features will be integrated into a state-of-the-art next generation gasifier capable of being economically competitive at a relatively small scale.

Title: *R&D Activities at PNNL, Including Technical Support, Wet Gasification, and Liquid Fuels Gasification and Pyrolysis*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key: Energy and Water Development
Recipient: Pacific Northwest National Laboratory (PNNL)
FY03 Plan ($): 2,200,000.00

Description:
The purpose of this project is to develop more efficient means of converting biomass into useful fuels by thermochemical means. Specifically, one task area involves developing a means to handle manure and the wet organic residue from ethanol fermentation, low-cost sugar production and other biorefinery concepts based on lignocellulosic biomass feedstocks. The residue needs to be disposed and, in the process, residual energy content needs to be recovered. Pressurized aqueous phase gasification provides an energy efficient mechanism for effectively breaking down the organic residue and producing a useful fuel gas product. Also, a second task area addresses development of processing chemistry to upgrade biomass fast pyrolysis oils to useful

fuels through catalytic means, such as hydrogenation. Finally, in a third task area, new methods will be developed for catalytic conversion of syn-gas from biomass gasification to liquid fuels.

One objective of this research is to advance the Low-Temperature Hydrothermal Gasification (LTHG) concept and make it available for use with wet biomass feedstocks, such as manure and ethanol fermentation residue. LTHG is more than just a gasification system as it can be integrated into an existing plant to solve several energy and environmental needs. LTHG is a unique thermocatalytic gasification concept, which converts wet organic residues to medium-Btu fuel gas (methane and carbon dioxide); cogeneration and reduction in solid waste handling can also be achieved. The catalytic system operates at high pressure (2000 to 3000 psig) and low temperature (300 to 350^{o}C) compared to conventional gasification approaches. LTHG is distinctive in its application to wet organic residues and no biological or thermal processes exist that have the potential to provide the overall systems impact of LTHG. This process will not only improve the overall process efficiency of ethanol production, but it will address the requirement for wastewater treatment inherent in the fermentation. In addition, the technology has potential for use in energy recovery from other wet biomass processing residues from sugar production processes and biorefinery concepts.

For this LTHG process development, research will be conducted in existing bench-scale, batch and continuous-feed reactor systems at PNNL to evaluate new catalysts with the high-moisture biomass feedstocks, develop catalyst deactivation and lifetime data, and determine kinetic parameters for the conversion of a variety of wet biomass feedstocks. An existing scaled-up reactor system (40 gal/day) will be operated at PNNL to determine the effects of scale-up on the process with the new catalysts and high-moisture biomass feedstocks. The process test results will be used to design a conceptual commercial processing plant and develop a preliminary capital cost. In the out years of FY2005 and beyond, design and construction of a cost-shared process demonstration plant is envisioned.

A second objective of this research is to advance the upgrading of biomass fast pyrolysis oils to higher value liquid fuels. Previous studies in this area have focused on the use of petroleum refining technology for analogous processing steps for the pyrolysis oil. The progress in this field advanced to the level of laboratory demonstration of such processing systems with useful catalysts and processing parameters identified. However, recent developments in catalyst formulation, specifically derived for use with biomass derived materials in the presence of large amounts of water, are now expected to provide improvements to the overall processing efficiency through reduced hydrogen requirements and reduced processing severity with improved catalyst longevity.

For this fast pyrolysis oil upgrading process development, research will be conducted in existing bench-scale, batch reactor systems at PNNL to evaluate new catalysts with the improved fast pyrolysis oil feedstocks and feedstock fractions. Following a reactor design exercise based on previous processing results and new design concepts, a bench-scale continuous flow reactor will be assembled (reassembled) and operated to determine kinetic parameters for the conversion and catalyst deactivation and lifetime data. The process test results will be used to provide a new basis for process economics and a detailed assessment will be undertaken.

The third objective of this research is to advance the production of liquid fuels from syn-gas derived from biomass gasification. More precisely, the objective of this task area is to develop novel micro technology-based processes for producing biomass-derived transportation fuels.

Conventional gas to liquid technology is only economically attractive at a large-scale (for example, >200,000Bbl/D), and is suitable for petroleum-derived feedstock. Biomass-derived feedstock, on the other hand, has the nature of small scale. Therefore, we further wish to demonstrate that the processes based on micro channel reactor technology are potentially cost-competitive at the small scale. Three liquid fuel types will be investigated: Fischer-Tropsch (FT) gasoline; single reactor sequential synthesis of methanol (MeOH) and dimethylether (DME); and synthesis of higher alcohols, such as ethanol, propanols, or butanols. The specifics of the objective include:

?? Development of highly active and selective catalysts suitable for micro channel reactors,
?? Identification and optimization of process conditions unique to the biomass-derived syn-gas,
?? Development of a highly intensified and cost-effective micro channel-based reactor for syn-gas to fuel conversion, and
?? Analysis of process economics and market based on biomass derive gas-to-liquid processes using micro channel technology.

Title: *Capital Equipment*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key:
Recipient: National Renewable Energy Laboratory (NREL)
FY03 Plan ($): 1,220,000.00

Description:

Title: *Gasification of Iowa Switchgrass (Earmark)*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key:
Recipient:
FY03 Plan ($): 496,750.00

Description:
This project will continue research on methods to gasify switchgrass for the production of energy.

Title: *Biomass Gasification Facility in Birmingham, AL (Earmark)*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key: Energy and Water Development
Recipient: Biomass Gasification Research Facility
FY03 Plan ($): 1,987,000.00

Description:
This project will fund research in biomass gasification to convert a wider variety of biomass

resources into useful energy.

Title: *Analytical Studies and Program Integration at NREL Related to Syngas Platform*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key: Energy and Water Development
Recipient: National Renewable Energy Laboratory (NREL)
FY03 Plan ($): 1,700,000.00

Description:
Many commercial processes exist for fuels, chemicals, and power from syngas. NREL is conducting analysis in support of research on the biomass syngas conversion processes. This will include the technical and economic analysis necessary to support R&D efforts and to enable successful integration with existing gas-to-liquids technologies.

Title: *Polyols Research and Development*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key:
Recipient: Pacific Northwest National Laboratory (PNNL)
FY03 Plan ($): 474,925.00

Description:

Title: *High Pressure Combinational Catalysis Unit*

Roadmap: **THERMOCHEMICAL CONVERSION**
Budget Key:
Recipient: Pacific Northwest National Laboratory (PNNL)
FY03 Plan ($): 1,500,000.00

Description:

BIOCONVERSION

Title: *Development of Improved Chemicals and Plastics from Oilseeds*

Roadmap: **BIOCONVERSION**
Budget Key: Interior
Recipient: Dow Chemical
F**Y03 Plan ($):** 794,374.00

Description:
The overall objective of this project is to develop the technology necessary for the production of novel and improved chemicals and plastics from seed oils. Such bio-based materials must be competitive, both with respect to cost and performance, with similar materials currently on the market that are produced from conventional petrochemical feedstocks. To achieve this objective, research will be conducted in the areas of plant science, crop production, processing, and utilization.

Creation and eventual large-scale cultivation of dedicated industrial oilseed crops for the production of specialty monomers that can be polymerized into novel, high performance materials is envisioned in this project. Research to enable this vision will include plant genomics, biochemistry, and metabolic engineering along with specialized crop development through breeding for improved agronomic performance. In addition, the goal is to put into place an infrastructure that will support the continuous back-integration into plants of novel materials that have been designed as a result of direct marketing needs. The specific tasks to accomplish this goal include: (1) Plant Science: Cater Genomics, Biochemistry, and Metabolic Engineering, (2) Production: Development of an Industrial OilSeed Crop, (3) Processing: Separation, Transesterfication, and Catalysis of Oleic, Rincinoleic and Other Fatty Acids, and (4) Utilization: Life Cycle Analysis, Modeling and Market Research.

Title: *Affordable Resins and Adhesives from Optimized Soybean Varieties*

Roadmap: **BIOCONVERSION**
Budget Key: Interior
Recipient: University of Delaware
FY03 Plan ($): 912,744.00

Description:
The efforts under this project include the following tasks: research, develop, scale-up, and commercialize low-cost soy oil-based adhesives and resins; research, develop, scale-up, and commercialize low-cost soy flour/protein-based adhesives; identify chemical composition, structure-function, and DNA markers of soybean oil/protein and soybean varieties that are favorable for adhesive properties; improve adhesion performance of soy oil/flour/proteins interactions by chemically modification and computer simulation; explore and develop new applications of soy oil-based adhesives and resins; and conduct commercial feasibility testing of soy oil/flour/ protein adhesives and resins.

The objective of this research is to use a systematic approach to develop the fundamental science in support of the corporate strategic partnerships that will impact a $50B market by providing an affordable replacement for petroleum-based materials with bio-based environmentally friendly and high-performance sustainable materials. We have prepared four resins during the first year, using two manufacturers. Two maleinated resins were prepared at Dock Resins, who is a continuing partner in our project. These resins were characterized and found to meet our quality standards. The next step would be to increase the batch size. The lowest cost resin is based on soybean oil monoglyceride, which has been maleinated. A resin with greater strength and higher softening temperature is based on the pentaerythritol monoester, which has been maleinated. Both of these resins have a high acid number, which can limit their use with certain reinforcing fibers. Two acrylated resins based on soybean oil have been scaled up for the PSA trials. The acrylated epoxidized soybean oil (AESO) has been formulated for our use by a supplier and sampled to our partners. The acrylated oleic acid methyl ester (AOME) has been scaled up for use in pressure sensitive adhesives (PSA). We have evaluated more than 20 different formulations of fibers for the fiber reinforced beams effort and resins for housing applications. The best engineering unit-beam properties were obtained with cellulose fibers derived from recycled newspapers and cardboard, interlaced with chicken feather mats, and infused with resin using Vacuum Assisted Resin Transfer Molding (VARTM). We continue to work with companies to determine the potential of these resins in a wide variety of applications from foams, with our partner, Diab, to natural composite with our partner Monvigro.

Title: *Industrial Membrane Filtration and Short-Bed Separation Systems for Separating Monomers from Heterogeneous Plant Materials*

Roadmap:	**BIOCONVERSION**
Budget Key:	Interior
Recipient:	Idaho National Engineering and Environmental Laboratory (INEEL)/Amalgamated Research
FY03 Plan ($):	520,000.00

Description:
A two-phased approach is proposed for the research and development described in this project. The first level of study involves testing the new concepts at the bench level. The bench-scale evaluations provide fundamental understanding of the processes, building and testing small prototype systems, and determining the efficiency of the novel processes. The second level of study, macro-level, requires building larger systems that directly simulate industrial operations and provide validation of performance to minimize financial risk during commercialization. The project goals and scope include:

- Provide low-capital alternatives to conventional crop-based purification/separation processes, and
- Develop each process to the point that transition to commercial operation will be low risk.

Testing and optimizing screening equipment will be studied as a pretreatment method for membrane filtration. The project will conduct long-term testing with a hybrid membrane system using commercial-size membrane modules. Tests will be done on new experimental, more durable, high-temperature spiral modules manufactured by Koch Membrane Systems. An optimized control strategy and a definition of the regimes of operations will be made. The

project will build a corrosion resistant, fully automated pilot fractal installation for evaluation of the concept of short bed chromatography and tests will be made on several model solutions (i.e. raw beet juice, hydrolysis synthate). The effect of bed height and recirculation velocities on system performance will be investigated. The best modes of operation for the new type of equipment will be determined. A research program with industrial prototypes of ion-exchange equipment using high-density fractal distributors that reduce equipment size ten-fold compared to conventional systems will be carried out. The geometry of channels and outlets in the fractal distributors will be optimized by using INEEL's computational fluid dynamics (CFD) software and expertise to reduce the pressure drop and improve efficiency of fluid distribution. Modeling will also be included for novel distributor arrangements as well as fluid outlet points. A prototype of improved fractal distributors will be manufactured and tested.

Title: *Development of Microorganism for the Fermentation of Agricultural Feedstocks to Chemicals*

Roadmap: **BIOCONVERSION**
Budget Key: Interior
Recipient: Cargill Dow Polymer
FY03 Plan ($): 375,426.00

Description:
The project objective is to develop a xylose fermenting microorganism for the production of lactic acid and ethanol by genetically engineering Cargill Dow's acid tolerant microorganism to ferment xylose.

Two different approaches will be taken. One of the approaches will make use of the xylose utilization pathway xylose reductase (XR) – xylitol dehydrogenase (XDH) – xylulokinase (XK) and the other will make use of xylose isomerase (XI) to overcome possible redox imbalance in the pathway. The statement of work includes the following tasks: (1) improve xylose to lactose fermentation of Strain M1, (2) improve xylose to lactate fermentation of Strain N1, (3) construct xylose to lactic fermentating Pichia stipitis as benchmark strain, (4) screen for isolate eukaryotic xylose isomerases, (5) construct xylose to lactate fermenting microorganisms utilizing novel XI(s), (6) rough biochemical characterization of chosen xylose pathway enzymes, (7) tools for genetic engineering of most promising strains, (8) genetic engineering of new host species for xylose to lactic fermentation, and (9) improvement of most promising strains for Task 1,2,5, or 8.

Title: *Sugar Platform Integration*

Roadmap: **BIOCONVERSION**
Budget Key: Energy and Water Development
Recipient: National Renewable Energy Laboratory (NREL)
FY03 Plan ($): 4,472,383

Description:
The overall objective is to investigate enzymatic cellulose hydrolysis-based biomass-to-ethanol conversion process technology based on a large-scale domestic feedstock (corn stover is the model feedstock). The goal is to exploit the improved, lower-cost cellulase enzymes being

developed under cost-shared subcontracts by Genencor and Novozymes to reduce the cost and risk of enzyme-based process technology. The objectives of FY03 work are to advance core process integration knowledge and to use process analysis tools to improve our understanding of economic risk. Experimentally, the focus is on improving our fundamental understanding about the complex interactions between feedstock characteristics and thermochemical pretreatment and enzymatic cellulose conversion performance. Analytically, the focus is on developing better analysis tools to facilitate process evaluation and optimization as well as to learn from studies of similar processes via collaborations.

In addition, a no-funds CRADA is anticipated to be established with DuPont. This is anticipated to be the first year of a four-year research program to provide a technical foundation for DuPont's proposed Integrated Corn-based Bioproducts Refinery. The objectives of the NREL work will be to develop a corn stover/fiber pretreatment scheme and microbial biocatalysts that integrate with enzymatic saccharification.

The DuPont CRADA is the result of a bioenergy solicitation award for a proposal entitled "Integrated Corn Based Biorefinery." Participants in this project are DuPont, Diversa, John Deere, Michigan State University, and NREL. NREL's role includes pretreatment, chemical analysis, and strain development. The pretreatment efforts involve the development of a mild pretreatment approach and will be developed in concert with Diversa's enzyme discovery and development efforts. The pretreatment effort will involve a bench scale program, including development of rapid chemical analysis methods specifically for these pretreated feedstocks, followed by scale up in NREL's PDU, and, eventually, to a dedicated semi works facility built and operated by DuPont. The strain development efforts involve the collaboration of scientists and engineers at DuPont and NREL to generate a superior ethanologenic *Zymomonas mobili*s. The work is scheduled to be performed over a four-year period. The vast majority of work examining the capabilities of *Z. mobilis* for fermentation of biomass hydrolysates involves dilute acid pretreatments. The inhibitors generated by the pretreatments developed for this project are anticipated to be different than those in dilute acid pretreatment.

Title: *Sugar Platform Advanced Biomass R&D Products from Sugars: Fermentation Platform*

Roadmap: **BIOCONVERSION**
Budget Key: Energy and Water Development
Recipient: National Renewable Energy Laboratory (NREL)
FY03 Plan ($): 1,215,451.00

Description:
Arabinose Yeast - Characterization of S. cerevisiae strains engineered to express bacterial *ara*A, *ara*B, and *araD* genes had shown that one of the major deficiencies for arabinose fermentation in this yeast species is poor transport of L-arabinose. During the 2001-2002 researchers identified some yeast species that have suitable L-arabinose transport. The emphasis of the FY03 research will be to identify an efficient L-arabinose transporter in an L-arabinose-utilizing yeast. By using genetic and molecular biology techniques, researchers will isolate, engineer, and express the L-arabinose transporter in *Saccharomyces cerevisia*e.

Catalytic Processing - The overall objective of this task is to evaluate catalytic sugar conversion processes for the production of novel products in a biorefinery setting. The development of

catalysts for converting sugars into higher value products is only it its infancy, especially when compared to today's petrochemical counterparts. Key barriers for the development of new catalysts include the lack of catalyst systems that provide high selectivity to the desired product and the lack of a fundamental understanding of how reactions take place in the aqueous phase. Catalysis offers the potential for process efficiency, "greener" unit operations, and high selectivity and control of reactions. Moreover, "catalysis" is a very broad term, and encompasses efforts using transition metals, novel acid and base systems, and biocatalysis. Hybrid processes, for example, containing both metal catalyzed and biochemically-catalyzed steps, are possible.

Title: *Sugar Platform Advanced Biomass R&D: Cellulase Enzymes*

Roadmap: **BIOCONVERSION**
Budget Key: Energy and Water Development
Recipient: National Renewable Energy Laboratory (NREL)/Genencor/Novozymes
FY03 Plan ($): 9,972,898.00

Description:
This task involves three subtasks and subcontract research efforts with Genencor and Novozyme. Subtasks include:

- The objectives of this subtask are to focus on the development of non-competitive, fundamental science necessary to accelerate the commercialization of cellulases in the context of near-term biorefineries (FY2003 to 2006). We will additionally work to ensure that sound scientific foundations exist for mid- and longer-term technology improvements (i.e., FY2010 and beyond). In order to accomplish these goals, industrial partnerships and collaboration with academia are necessary. To be effective, this program must balance the requirement for reaching enzymatic performance goals in a timely manner, with the need to attain a sufficient understanding of cellulase structure and mechanism to be able to ask the appropriate questions experimentally and understand natural limits. Special effort will be made to efficiently convey new understanding to the public sector through publications, presentations, and newsletters.

- Continue to ensure that appropriate assays and techno economic performance metrics are maintained and utilized to evaluate and quantify cost reduction progress as stated in the Integrated Tasks section of the subcontracts. Potential tests to be performed include numerous kinetic, differential scanning micro calorimetric (DSC), compositional, and other physico- chemical analyses, in addition to process relevant evaluations of complete enzyme preparations. Researchers involved with the Enzyme Sugar Platform task will continue to be involved, along with the subcontractors themselves, in establishing process relevant performance assays. At the end of each subcontract's three-year performance period, we will quantitatively measure the improvement that has been achieved in cellulase performance in terms of the decrease in loading of enzyme protein required to achieve the target extent of conversion of the cellulose in pretreated biomass; this will happen for GCI in FY03. Process engineers will apply this and related process information to quantify progress using the previously established Enzyme Cost Metric. Bimonthly meeting will continue to be conducted, and beyond this email and phone correspondence will be used extensively to ensure that effective communications are being maintained between the subcontractors, ESL and ESP task researchers, and DOE.

✍ Genencor International and NREL will characterize a number of glycosylhydolases previously identified by NREL for thermotolerance, substrate range, and specific activity. A modification is currently being negotiated to extend the work to include structure-function characterizations of cellobiohydrolase I enzymes.

Title: *Sugar Platform Advanced Biomass R&D: Pretreatment*

Roadmap: **BIOCONVERSION**
Budget Key: Energy and Water Development
Recipient: National Renewable Energy Laboratory (NREL)
FY03 Plan ($): $3,304,268.00

Description:
Advanced Pretreatment - The Advanced Pretreatment Task is comprised of two distinct elements: 1) a fundamental element that seeks to understand biomass structure and reactions, and 2) an applied element that focuses on advanced pretreatment process considerations and capabilities. Efforts in FY03 will lead to a more mechanistically correct understanding of biomass disaggregation and hydrolysis through use of molecular models and improved ability to close mass balances in a variety of reaction configurations. Continued support of the Biomass Refining Consortium for Applied Fundamentals and Innovation (CAFI) will lead to the availability of more rigorous comparative process data and economics for a variety of pretreatment approaches. The unique pilot scale pretreatment capabilities in the Process Development Unit (PDU) will be further enhanced by gathering process performance data for the hot separation and washing process using the recently installed Pneumapress® pressure belt filter.

Hemicellulase and Accessory Enzymes - This project is primarily designed to determine if biomass conversion to free sugars can be carried out more efficiently with a greater variety of enzymes and less severe pretreatment. The overarching goal is to determine if addition of non cellulase enzymes to pretreated biomass can a) render the biomass more digestible in an economic manner, and b) enable equivalent cellulose digestion by cellulases acting on biomass pretreated with different severities. This task has two objective-oriented subtasks:

- **Subtask 1. Pretreated Substrate Evaluation/Modeling:** Evaluate the cost effectiveness of enzymes in advanced pretreatment depolymerization of non-cellulosic polysaccharides and enhancement of cellulose digestion by cellulases.
- **Subtask 2. Enzyme Activity Profiling/Purification:** Qualitative and quantitative determination of hemicellulase and accessory activities present in commercial cellulase preparations.

Clean Fractionation - The evaluation of clean fractionation technology will 1) develop credible cost estimates for the overall separation process and each fraction available, 2) determine product classes that may be addressed by the different components from the pretreatment, 3) demonstrate that CF is a cost-effective crosscutting technology for both the advanced pretreatment and Products from Sugars task areas, and 4) identify outyear R&D needs for successful incorporation of these novel pretreatment technologies in the biorefinery and as a source of biorefinery raw materials. The evaluation will also be used to better define product opportunities for each of the CF fractions derived from a variety of lignocellulosic and agricultural feedstocks. Given that CF

is applicable to a wide variety of biomass feedstocks, the results of this analysis will be of value to advanced pretreatment task areas, as different methods for biomass separation are evaluated.

Biomass Analysis Tools and Methods:

- **Subtask 1. External Analytical:** This subtask's objective is to coordinate the external analytical chemistry support activities for Sugar Platform R&D.
- **Subtask 2. ASTM Activities:** This subtask's objective is to continue to participate in ASTM Subcommittee E48.05 (Biotechnology Committee E48, Biomass Conversion Subcommittee 05) in order to foster the development of consensus standards and test methodologies that facilitate validation and quality control of biomass conversion processes.
- **Subtask 3. Rapid Biomass Analysis:** The rapid analysis subtask's objective is to support the Sugar Platform's Advanced R&D and Systems Integration and Production goals by developing, refining, and validating rapid and inexpensive methods for determining the chemical composition of biomass samples before and after pretreatment, as well as during subsequent bioconversion processing.

Title: *PHAs in Plants (Biomass Biorefinery for Production of Polymers and Fuel)*

Roadmap: **BIOCONVERSION**
Budget Key: Interior
Recipient: Metabolix
FY03 Plan ($): 1,400,000.00

Description:
The goal of the Biomass Biorefinery project is to demonstrate the production of polyhydroxyalkanoates (PHA) polymers in green tissue plants, recover the polymers, and capture the energy value of the residual biomass. The Biomass Biorefinery project will assist the Department of Energy program for enhancing economic competitiveness, reducing energy consumption, and reducing the environmental impact of petroleum-based products. Within this project, Metabolix and its project partners will demonstrate PHB production in switchgrass using a multi-gene construct encoding all three enzymes of the PHB pathway using nuclear transformation and plastid targeting peptides. In parallel, an optimized construct in which each of the PHB genes is expressed under the control of a different plant promoter will be developed. Included in this aspect will be the use of a proprietary gene encoding a hybrid enzyme with the activity of the first two enzymes in the PHB pathway in order to reduce the potential for gene silencing. These efforts are focused on minimizing the number of transgene constructs, which have to be introduced into the plant to ultimately produce the desired copolymer.

Title: *Miscellaneous Capital Equipment*

Roadmap: **BIOCONVERSION**
Budget Key:
Recipient: HPCC-MS
FY03 Plan ($): 561,750.00

Description:

BIOREFINERY INTEGRATION

Title: *Collaboration with USFS Forests Products Laboratory on Gasifier Demonstration*

Roadmap: **BIOREFINERY INTEGRATION**
Budget Key: Energy and Water Development
Recipient: National Renewable Energy Laboratory (NREL)
FY03 Plan ($): 2,000,000.00

Description:
This project involves collaboration with the U.S. Forest Service's Forest Product Laboratory. The objective of this task would be to demonstrate the feasibility of using small modular biopower (SMB) to produce electricity at the 15 – 25 kW scale using residues (wood chips) from forest fuel reduction activities. Demonstration projects will take place in 5 to 10 rural communities that are actively engaged in forest fuel reduction projects. To accomplish the demonstrations in a reasonable time, three to four demonstration prototypes will fabricated. Potential sub-tasks include preliminary feasibility analysis, SMB design, SMB fabrication, and demonstration.

Title: *Corn Ethanol Production Improvements*

Roadmap: **BIOREFINERY INTEGRATION**
Budget Key: Energy and Water Development
Recipient: National Renewable Energy Laboratory (NREL)/Advanced Corn Mills-USDA/Broin/High Plains
FY03 Plan ($): 840,000.00

Description:

Advanced Corn Mills - The overall goal of this task is to find new, economically viable processes that generate additional co-products and improved yields from a bushel of corn when applied in conjunction with current dry milling technology in order to improve dry mill profitability. New technologies for corn utilization are being developed and tested for their economic and technical viability by USDA, University of Illinois, MBI and NREL. Corn fiber can be separated from the starch component prior to processing utilizing a liquid soaking process or by mechanical de-germing processes. The fibrous residue can then be converted into various products, including additional ethanol via pretreatment followed by saccharification and fermentation. This process could improve the economics of a dry mill operation by increasing the amount of ethanol produced from the extracted fiber and lead to the development of new co-products. Work in FY03 seeks to continue prior evaluation work in this area to include an expanded series of pretreatment samples in order to better characterize the performance of Quick Fiber and other corn fiber residues. Process engineering will be performed using the obtained results to develop a techno-economic model in order to determine the economic potential of the candidate process options.

Broin - The objectives of the NREL work within the contract will be to develop a conversion scheme to increase the total value of second-generation dry mill products.

High Plains – Will develop process technology that utilizes advanced biorefining techniques to improve dry mill efficiency and profitability. This technology will enable a more economical, sustainable industry and will achieve significant additional petroleum displacement by decreasing the process petroleum use per gallon of ethanol produced and increasing overall ethanol production and availability. In FY03, this project will complete a preliminary investigation of process options, make significant progress towards demonstrating pretreatment at the bench scale, and begin developing an applicable rapid analysis method.

Title: *GovWorks/Department of the Interior (Obligated to the Six Projects)*

Roadmap: **BIOREFINERY INTEGRATION**
Budget Key:
Recipient: GovWorks/Department of Interior
FY03 Plan ($): 1,265,000.00

Description:
Funding to be obligated to the six integrated biorefinery projects.

Title: *A Second Generation Dry Mill Biorefinery*

Roadmap:
Recipient: Broin and Associates Inc.
FY03 Plan ($): 1,596,000.00

Description:
Broin and Associates, Inc. will work in cooperation with DOE in a joint project to research and develop a dry mill "biorefinery" process for enhancing the economics of existing ethanol dry mills by creating additional co-products and increasing ethanol yields. In this "second generation" dry mill, Broin will fractionate the bran, germ, and endosperm in the incoming corn feed using proprietary processes and equipment. This revolutionary mechanical separation will enable flexibility in feedstock utilization, substrate conversion, and fermentation process, while expanding options for value added co-product production. With the assistance of the National Renewable Energy Laboratory (NREL), Broin will investigate at bench and pilot-scale the technical and economic feasibility of converting the hemicellulosic and cellulosic fractions of the extracted corn bran to ethanol as well as upgrading the bran and endosperm fermentation residues to high protein animal feeds.

Title: *A New Biorefinery Platform Intermediate*

Roadmap:
Recipient: Cargill, Inc.
FY03 Plan ($): 2,009,000.00

Description:
Cargill, through collaboration with their partners Codexis, Inc. and Pacific Northwest National Laboratory (PNNL), will develop a new bio-based platform technology to produce a portfolio of products based on 3-hydroxypropionic acid (3-HP) produced by the fermentation of carbohydrates. For the first step, Codexis, a subsidiary of Maxygen, Inc. and a leader in DNA evolution technology, will optimize the genes and pathway for production of 3-HP. Cargill will then optimize the organism and fermentation process. For the second step, Cargill will partner with the Chemical Process Development Group at PNNL to screen catalysts and develop process flowsheets, simulations, and economic estimates for a number of 3-HP derivatives. This project will deliver an organism and process for 3-HP production, as well as catalysts, and complete process concepts suitable for piloting and scale-up for industrial production.

Title: *Making Industrial Bio-Refining Happen*

Roadmap:
Recipient: Cargill Dow, LLC
FY03 Plan ($): 9,041,000.00

Description:
Cargill Dow, in partnership with Iogen and Shell Global Solutions, will develop and pilot-scale a demonstration biorefinery project in collaboration with wheat, corn, and rice grower organizations; national labs and universities; as well as environmental and social non-government organizations. The project focuses on process and fermentation technologies, as these will constitute the "heart" of the economically and environmentally sound biorefinery of the future. The major goals of the project are to develop and validate process technology and sustainable agricultural systems that will cost effectively produce sugars and chemicals such as lactic acid and ethanol from lignocellulosic biomass, and ensure that growers and grower organizations have a first opportunity to participate in the commercial development of the resulting biorefinery technology.

Title: *Integrated Corn-Based Bio Refinery (ICBR) Project*

Roadmap:
Recipient: E.I. du Pont de Nemours & Co., Inc. (DuPont)
FY03 Plan ($): 4,094,000.00

Description:
DuPont will work in cooperation with DOE in a joint project to develop a new form of biorefinery, the Integrated Corn-Based Bio Refinery (ICBR). The ICBR process will bring new technology to the conversion of corn and stover into fermentable sugars for parallel production of added value chemicals such as 1,3 propanediol for the high performance polyester, Sorona ™, and fuel ethanol. In the ICBR approach, this combination of feedstocks and products sets an example for production of other added value chemicals along with ethanol. The project encompasses the following tasks: Process Design, Economics and Testing; Saccharification: Pre-treatment and Enzymes; Ethanologen Development; and Further Develop DuPont PDO Organism For Complex Hexose Substrate Utilization. DuPont will collaborate with Diversa and the National Renewable Energy Laboratory (NREL) on the project.

Title: *Advanced Biorefining of Distiller's Grain and Corn Stover Blends: Pre-Commercialization of a Biomass–Derived Process Technology*

Roadmap:
Recipient: High Plains Corporation
FY03 Plan ($): 3,211,000.00

Description:
High Plains Corporation (HPC), in collaboration with Novozymes North America, Inc. (NZNA), VTT-Finland (VTT), and the National Renewable Energy Laboratory (NREL), will develop a novel biomass-derived process technology that utilizes advanced biorefined Distiller's Grain (DG) and Corn Stover (CS) blends to achieve significantly higher ethanol yields while maintaining the protein feed value. This technology will enable a more economical, sustainable industry; reduce petroleum use per ethanol gallon produced; and increase the availability of ethanol. The project will demonstrate at bench and pilot scale, a viable pretreatment process for DG and CS to convert residual starch, cellulose and hemicellulose to ethanol and high-protein feed. Bench-scale and small pilot-scale process analysis will undergo Stage Gate economic criteria for advancement into large pilot-scale integration. The bench and small pilot scale phases of the project will be performed at the NREL and NZNA facilities. Final integration of the large-scale pilot facilities will occur at the High Plains York, Nebraska (HPY) plant, a 50 million gallon per year corn dry-mill plant.

Title: *Separation of Corn Fiber and Conversion to Fuels and Chemicals, Phase II: Pilot-Scale Operation*

Roadmap:
Recipient: National Corn Growers Association
FY03 Plan ($): 1,054,000.00

Description:
The multidisciplinary project team from Archer Daniels Midland (ADM), the National Corn Growers Association (NCGA), and Pacific Northwest National Laboratory (PNNL) intend to economically derive high-value chemicals and oils from lower value corn fiber. In the process, starch is recovered as glucose, which is then converted to ethanol. The hemicellulose fraction is hydrolyzed to yield the 5-carbon sugars, arabinose and xylose. The xylose is converted to ethanol, and the arabinose is catalytically converted to ethylene glycol, propylene glycol, and glycerol. In addition, high-value oil components, sterols and stanols, are recovered. The residual fiber (~50% by weight of the original corn fiber) contains primarily cellulose and protein. The protein concentration of the residual fiber is approximately double that of the starting material and, therefore, has an increased value (i.e., corn fiber value is roughly proportional to protein content).

The subject of this proposal is pilot-scale testing to validate the process prior to full-scale commercial implementation. The proposed pilot-scale operation phase will entail bench-scale process optimization testing, system design, system procurement and fabrication, system construction, shakedown testing, actual testing, and an economic evaluation of the integrated

process. Piloting of the process is necessary so that the technical (i.e., processing and operation of key equipment) and economic aspects of the process can be more thoroughly evaluated prior to commercialization of the process.

Title: *Corn Bioproducts (Earmark)*

Roadmap: **BIOREFINERY INTEGRATION**
Recipient: National Corn Growers Association
FY03 Plan ($): 572,000.00

Description:

Title: *Mixed Waste Biorefinery Using Thermal Depolymerization in Colorado (Earmark)*

Roadmap: **BIOREFINERY INTEGRATION**
Budget Key: Energy and Water Development
Recipient:
FY03 Plan ($): 2,483,750.00

Description:
This cost-shared project will support research and development for a biorefinery using mixed waste agricultural feedstocks. Research will be conducted on thermo-polymerization technologies and processes.

Title: *Combined Heat and Power in Minnesota (Earmark)*

Roadmap: **BIOREFINERY INTEGRATION**
Budget Key: Energy and Water Development
Recipient: Green Power Institute
FY03 Plan ($): 1,987,000.00

Description:
The Green Institute in Minnesota will conduct research on combined heat and power from biomass to increase the availability clean and efficiently-produced energy in industrial applications.

Title: *Center for Biomass Utilization*

Roadmap: **BIOREFINERY INTEGRATION**
Budget Key: Energy and Water Development
Recipient: University of North Dakota
FY03 Plan ($): 397,400.00

Description:
This effort will provide funding to the Center for Biomass Utilization at the University of North

Dakota to identify increased opportunities for efficient utilization of biomass resources. The Center for Biomass Utilization develops, demonstrates, and commercializes technologies that make use of biomass for electric power generation, transportation fuels, and chemical feedstocks. The technologies are focused on practical and economic reality within the framework of sustainable development and strict environmental protection.

Title: *Biomass Energy Resources Center in Burlington, VT*

Roadmap: **BIOREFINERY INTEGRATION**
Budget Key: Energy and Water Development
Recipient: Biomass Energy Resources Center
FY03 Plan ($): 496,750.00

Description:
This funding will assist in supporting the Biomass Energy Resource Center development in Burlington, Vermont. The Center is designed to support and facilitate the efficient development and use of biomass resources and technologies in the state.

Title: *Fibrowatt Mississippi Biomass Project*

Roadmap: **BIOREFINERY INTEGRATION**
Budget Key: Energy and Water Development
Recipient: Fibrowatt LLC
FY03 Plan ($): 496,750.00

Description:

This project will support development of a biomass-fired power plant in Mississippi.

The plant will generate 40MW from around 200,000-300,000 tons per year of poultry litter, and 100,000-200,000 tons per year of forest residues and other agricultural biomass. The plant will be located in the poultry growing area in central Mississippi.

Title: *Iowa Switchgrass at Agreed to Levels*

Roadmap: **BIOREFINERY INTEGRATION**
Budget Key: Energy and Water Development
Recipient: Chariton Valley
FY03 Plan ($): To be determined

Description:
This project will continue research on the potential for growing switchgrass on marginal land to be used as an input for alternative energy. Specific goals are to eventually use the switchgrass as a fuel to replace a portion of the coal burned at Alliant Power's (formerly IES Utilities) Ottumwa generating station.

Title: *Iroquois Bioenergy Cooperative (Earmark)*

Roadmap:	**BIOREFINERY INTEGRATION**
Budget Key:	Energy and Water Development
Recipient:	Iroquois Cooperative
FY03 Plan ($):	2,980,500.00

Description:

This funding will be used to help the Iroquois Bio-Energy Cooperative (IBEC) build the estimated $56-million facility, which will produce an estimated 40 million gallons of ethanol annually. The facility will be located in Jasper County, Indiana. In addition to its role in decreasing America's foreign oil needs, the plant will also provide a needed new market for corn growers and create an estimated 40 to 50 new jobs. It will draw corn from nine Indiana counties, including Lake, Porter, Jasper, Newton, Benton, LaPorte, Starke, Pulaski, and White.

It is estimated the new plant will consume 14 million bushels of corn each year. This will help farmers in the nine-county area, who must export most of their 128-million bushels of annual production. With less than half of the area's annual corn production being processed for food or industrial uses, corn growers in Northwest Indiana traditionally receive the lowest prices in the state for their crops.

Title: *Michigan Biotech Institute (Earmark)*

Roadmap:	**BIOREFINERY INTEGRATION**
Budget Key:	Energy and Water Development
Recipient:	Michigan Biotech Institute
FY03 Plan ($):	1,987,000.00

Description:
This research will support the Michigan Biotechnology Initiative to further capabilities for converting biomass to useful fuels and chemicals.

Title: *Mississippi Ethanol (Earmark)*

Roadmap:	**BIOREFINERY INTEGRATION**
Budget Key:	Energy and Water Development
Recipient:	Mississippi Ethanol
FY03 Plan ($):	2,980,500.00

Description:

Mississippi Ethanol will develop a method for gasifying biomass to produce heat, steam, ethanol, and power as well as to ferment the gases into petrochemical substitutes. The project will be located in Winona, Mississippi.

Title: *New FY 2003 Solicitation with USDA*

Roadmap:	**BIOREFINERY INTEGRATION**
Budget Key:	Energy and Water Development
Recipient:	To be determined
FY03 Plan ($):	5,000,000.00

Description:
Recipients to be determined.

END PRODUCTS & DISTRIBUTION SYSTEMS FOR BIOMASS RESOURCES

Title: *Renewable Diesel: Industrial Oils Platform Analysis*

Roadmap:	**END PRODUCTS & DISTRIBUTION SYSTEMS FOR BIOMASS RESOURCES**
Budget Key:	Energy and Water Development
Recipient:	National Renewable Energy Laboratory (NREL)
FY03 Plan ($):	1,500,000.00

Description:
The overall objective of this task is to reduce technical barriers that inhibit broader use of renewable diesel fuels through R&D. Specific technical barriers to increased use of biodiesel and ethanol-diesel blends are targeted under several subtasks. Industry outreach as well as DOE and Program Management support are also a part of this effort.

- **Biodiesel Oxidation Stability Technical Review Committee Meeting**: Results of the biodiesel oxidative stability study completed in FY02 will be presented to a technical review committee. Advice from the committee will be sought with respect to adequacy of the data for development of an oxidative stability standard for biodiesel. Meeting organized via subcontract

- **Testing of Biodiesel in EGR Engine** : Biodiesel produced from soy and yellow grease will be tested in an industry-supplied engine equipped with EGR to meet the 2004 EPA emission standards. Performed in-house.

- **Industry Outreach**: Continued liaison with the National Biodiesel Board and the E-Diesel Consortium.

Title: *National Agriculture-based Industrial Lubricants Center (Earmark)*

Roadmap:	**END PRODUCTS & DISTRIBUTION SYSTEMS FOR BIOMASS RESOURCES**
Budget Key:	Energy and Water Development
Recipient:	Industrial Lubricants Center, University of Northern Iowa
FY03 Plan ($):	993,500.00

Description:
Funding will support the University of Northern Iowa (UNI) Ag-Based Industrial Lubricants (ABIL) Research Program was initiated to research development of hydraulic and other industrial lubricants from soybean and other vegetable oils. The program receives support from state, federal, and private industrial partners. ABIL Research tests performance and chemistry of lubricants and hydraulic oils. Center activities include:

- Research and testing on crude and chemically modified vegetable oils according to ASTM and other industry standards.

- ?? Research and testing on additive packages to enhance vegetable-based lubricants performance.
- ?? Research and testing on genetically modified soybean and other seed oils for use in industrial applications.
- ?? Biodegradability, biotoxicity, and ecotoxicity testing of vegetable-based industrial lubricants.
- ?? Hydraulic training - ABIL is the only (Eaton) Vickers Certified Training Center in the state of Iowa (See testing and training links).

Title: *Oxydiesel Demonstration in Nevada and California (Earmark)*

Roadmap:	**END PRODUCTS & DISTRIBUTION SYSTEMS FOR BIOMASS RESOURCES**
Budget Key:	Energy and Water Development
Recipient:	AAE Technologies
FY03 Plan ($):	993,500.00

Description:

PLANNING AND ANALYSIS

Title: *Biomass Program Analysis*

Roadmap:	**PUBLIC POLICY MEASURES TO SUPPORT BIOMASS DEVELOPMENT**
Budget Key:	Energy and Water Development
Recipient:	Argonne, Brookhaven, National Renewable Energy Laboratory (NREL), Oak Ridge National Laboratory (ORNL)
FY03 Plan ($):	953,191.00

Description:
A variety of market analysis and market data collection activities will be performed, including:

- Interaction of ethanol/hydrogen/transportation fuel pathways.
- Developing the ability to model renewable markets in Central America.
- Improvements to integrated modeling NEMs and MARKAL.
- Improved characterization of biorefinery output markets and assumptions and data used for benefit estimates, and maintain models of key markets.
- Initial implementation of NAS framework in benefit estimates, final FY 2004 report and preliminary FY 2005 estimates to OMB, and priority improvements to economic benefits, including macroeconomic benefits of EERE.
- Update sector databooks and various legacy market sales databases, including REPIS and Green Power.
- Develop recommended market assessment approaches.
- Define security/reliability metrics, develop initial estimate with regard to fuels and electric, as well as work biomass model interface with NEMs and MARKAL.

Title: *Identification and Assessment of Biomass-based Chemicals and Materials to Guide Research in the Office of the Biomass Program*

Roadmap:	**PUBLIC POLICY MEASURES TO SUPPORT BIOMASS DEVELOPMENT**
Budget Key:	Interior
Recipient:	Pacific Northwest National Laboratory (PNNL), National Renewable Energy Laboratory (NREL)
FY03 Plan ($):	581,000.00

Description:
This effort is being conducted to guide biomass-based chemicals and materials in the Office of the Biomass Program. Depicted here under THERMOCHEMICAL CONVERSION, it would likely contain both bioconversion and thermochemical processes.

1. Long Term - Provide OBP and DOE with the ability to discriminate between options for biobased product production that address national needs, EERE and program objectives, congressional mandates and public law.
2. Short Term

a) Use process engineering analyses, strategic program needs and market value creation criteria to identify about ten high-value biomass based products that can be produced in an integrated biorefinery or stand-alone operations.
b) If resources permit, undertake conceptual process designs for selected products with more rigorous market and economic analyses to evaluate the specific R&D needed to pursue such product targets. Use of stage-gate analyses and RFPs could be used to accomplish this objective.

A key to this study will be to select criteria that will be used for screening potential targets. The approach involves selecting the criteria and then employing those screening tools as a decision-making tree for down selecting potential candidates. Figure 1 outlines the general flow of this process.

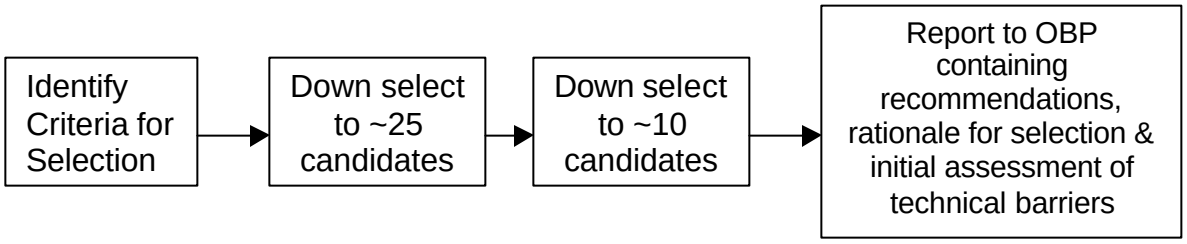

Figure 1 – Approach to selecting 10 target biobased products

PROCUREMENT AND MARKETS

Title: *BuyBio DOE/Other Federal Agencies Procurement Initiative*

Roadmap:	**PUBLIC POLICY MEASURES TO SUPPORT BIOMASS DEVELOPMENT**
Budget Key:	Energy and Water Development
Recipient:	Argonne National Laboratory (ANL)
FY03 Plan ($):	100,000.00

Description:
Assist in accelerating preferential purchases of biobased products by DOE procurement elements and other Federal agencies through interagency work group coordination, performance monitoring, and recognition.

EDUCATION INITIATIVE

Title: *Education Initiative*

Roadmap:	**PUBLIC POLICY MEASURES TO SUPPORT BIOMASS DEVELOPMENT**
Budget Key:	Interior
Recipient:	To be determined per results of solicitation
FY03 Plan ($):	1,000,000.00

Description:
In 1999, what was originally the Agriculture Industry of the Future Program in the Office of Industrial Technologies began an education initiative by conducting two solicitations. Eight universities were selected to create multi-disciplinary graduate-level education and research programs: Michigan State University, Iowa State University (2 grants), University of Georgia, Colorado School of Mines, Oklahoma State University, University of Nebraska-Lincoln, Kansas State University, and University of Missouri-Rolla. Grants ranging from $200,000 to $375,000 were used primarily to create a new multi-disciplinary curriculum, preparing science and engineering graduate students for the biobased products industry. Of special note, one of the university grant recipients has created an industrial energy management course and a fermentation engineering course that were offered in the spring of 2002. In the future, the Biomass Program plans to expand the biobased products education initiative to reach a broader audience.

Title: *Communication and Education*

Roadmap:	**PUBLIC POLICY MEASURES TO SUPPORT BIOMASS DEVELOPMENT**
Budget Key:	Energy and Water Development
Recipient:	
FY03 Plan ($):	878,000.00

Description:

Title: *Consortium for Plant Biotechnology Research Initiative (Earmark)*

Roadmap:	**PUBLIC POLICY MEASURES TO SUPPORT BIOMASS DEVELOPMENT**
Budget Key:	Energy and Water Development
Recipient:	Consortium for Plant Biotechnology Research
FY03 Plan ($):	1,987,000.00

Description:
CPBR's ERTT mission is to support basic biotechnology research and the development of new, commercially valuable technologies supportive of the long-term strategic goals of EPA. It is

anticipated that the Consortium will provide substantial environmental benefits through results such as:

- ?? growth of bioenergy and other crops with lower use of fertilizers, herbicides and pesticides;
- ?? production of commodity chemicals from renewables rather than from fossil fuels;
- ?? more efficient processing of biomass-based crops and wastes into biofuels;
- ?? new tools and techniques for to use in engineering or breeding desirable traits in crops;
- ?? assessment of the effects of genetically engineered organisms on the environment;
- ?? assessment of the transmissibility of genetically engineered traits; and remediation of polluted sites.

STATE AND REGIONAL

Title: *Regional Biomass Energy Program Management*

Roadmap:	**PUBLIC POLICY MEASURES TO SUPPORT BIOMASS DEVELOPMENT**
Budget Key:	Energy and Water Development
Recipient:	Regional Biomass Energy Programs
FY03 Plan ($):	880,500.00

Description:

Title: *State Technologies Advancement Collaborative (STAC)*

Roadmap:	**PUBLIC POLICY MEASURES TO SUPPORT BIOMASS DEVELOPMENT**
Budget Key:	Energy and Water Development
Recipient:	STAC
FY03 Plan ($):	1,500,000.00

Description:

The new State Technologies Advancement Collaborative (STAC) will promote research and deployment in innovative ways to produce, transmit and distribute energy and to use it more efficiently. The pact will make it easier for collaborative members to share information on research and to prevent wasteful duplication of efforts. By jointly funding selected projects, the Collaborative will be able to leverage funds and to simplify the path for promising technologies to enter the market. STAC is a collaborative with the Association of State Energy Research and Technology Transfer Institutions Inc. (ASERTTI) in Napa, California, the Department of Energy, ASERTTI and the National Association of State Energy Officials (NASEO).

Title: *EE Special Energy Project (SEP) State Grants*

Roadmap:	**PUBLIC POLICY MEASURES TO SUPPORT BIOMASS DEVELOPMENT**
Budget Key:	Energy and Water Development
Recipient:	To be determined per results of solicitation
FY03 Plan ($):	600,000.00

Description:
The Biomass Program is seeking state and local partners to help foster markets for biomass-based technologies. The Biomass Program is currently sponsoring R&D to develop advanced technologies for converting biomass to fuels, power, and other products (e.g., chemicals and materials). In order to achieve significant market penetration of these biomass-based

technologies, a variety of market conditioning efforts are needed. These include the development and implementation of innovative State and local incentives, efforts to increase consumer acceptance of biomass-based options, as well as efforts to increase support from farmers an industry. A primary barrier to the deployment of biomass technologies has been the cost competitiveness of these technologies relative to conventional fossil fuel-based alternatives. The Biomass Program has a particular interest in addressing harvesting, storage, and handling considerations for cellulosic biomass in efforts to reduce feedstock costs. In the context of market conditioning to foster significant penetration of biomass-based technologies and products, cost-shared activities will be sought in two areas: 1) outreach and information transfer to consumers, farmers, and industry; or 2) development of innovative state or local incentives that facilitate increased market penetration of biobased products and biomass-based technologies.

OTHER

Title: *Early Reallotment of FY 2002 Unobligated Balances for Earmark*

Roadmap: **OTHER**
Budget Key: Energy and Water Development
Recipient: Multiple
FY03 Plan ($): 5,622,000.00

Title: *Miscellaneous Corporate Initiatives*

Roadmap: **PUBLIC POLICY MEASURES TO SUPPORT BIOMASS DEVELOPMENT**
Budget Key: Energy and Water Development
Recipient: Headquarters
FY03 Plan ($): 4,324,170.00

Description:
Communications ($)
Small Business Innovative Research Program ($)
Corporate Initiatives ($)

* SEP Grants are reported in the State Grants section of this report.

Title: *FY 2003 EARMARK Reserve*

Roadmap:
Budget Key:
Recipient: Various
FY03 Plan ($): 4,900,000.00

Description:
Reserve funding for future earmarks(s).

Title: *FY 2003 Solicitation Reserve*

Roadmap:
Budget Key:
Recipient: TBD
FY03 Plan ($): 5,031,166.00

Description:
Reserve funding for future solicitation(s).

Title: *Program Direction*

Roadmap: **OTHER**
Budget Key: Interior, Energy and Water Development
Recipient: Multiple
FY03 Plan ($): 761,000.00

Description:
Includes travel, office equipment, program review, budget summit activities, Biomass Technical Advisory Committee support and travel, National Biomass Coordination Office support, and other management and program support.